

## A High dV Miniature Ion Thruster for SmallSat Primary Propulsion

Completed Technology Project (2017 - 2021)



## Project Introduction

CubeSats enable a wide range of important, low-cost space missions, leveraging increasing densification of electronics and communications equipment to perform tasks previously in the realm of much larger spacecraft. CubeSats in sizes of 3U-12U are a promising platform for future NASA exploration and science missions, including lunar remote sensing, NEO exploration, and planetary defense, but currently lack the high  $\hat{I}^{\text{V}}$  propulsion required for these exciting applications. Ion thrusters are currently the best option for low power, mN range EP as required for high  $\hat{I}^{\text{V}}$  SmallSat missions. These thrusters are inherently more efficient than other options such as RF or Microwave, and are capable of high total impulse. This work aims to realize these advantages at the low power, miniature scale. I propose a multi-pronged approach for the improvement of the TRL 4 MiXI thruster for miniature spacecraft and precision flying applications. By incorporating lessons learned from the UCLA Plasma and Space Propulsion Lab's MARCI experiment, the discharge efficiency of MiXI will be improved to that of larger, conventional ion thrusters, resulting in a final system with  $>70\%$  total efficiency, under 100W operation,  $I_{sp} > 1500s$ ,  $>1000m/s$   $\hat{I}^{\text{V}}$  capability on 3-12U CubeSats, and 0.1-1.55mN thrust. Computational simulations and experimental validations will be undertaken to optimize the MARCI discharge for a miniature ion thruster, which will then be integrated into the heritage MiXI thruster. New grids will be designed for the resulting change in discharge conditions. Flight-worthy miniature cathodes will be implemented as electron sources for the discharge and beam neutralization while minimizing propellant and power usage. The resulting enhanced MiXI will be characterized within the Plasma & Space Propulsion Lab's Miniature Electric Propulsion Test Facility to establish throttle curves and performance. Lifetime will be assessed through a 1000-hour grid life validation test and extended to 30000 hours through NSTAR models. Finally, the thruster will be assembled into a complete propulsion subsystem and tested within a spacecraft analog in simulated space conditions for TRL 6 maturation. This development effort promises to enable low power missions with high  $\hat{I}^{\text{V}}$ , high propellant efficiency, and high electrical efficiency. Miniature ion thruster development is a NASA identified enabling technology for missions in planetary science, heliophysics, and astronomy, with the primary application of SmallSat and CubeSat primary propulsion. This work will address the primary obstacle for widespread adoption of miniature ion thrusters. This will be accomplished by dramatically improving the electrical efficiency of MiXI through the implementation of a novel discharge topology, and demonstration of a propulsion system capable of  $>1,000m/s$   $\hat{I}^{\text{V}}$  for SmallSat missions.

## Anticipated Benefits

This development effort promises to enable low power missions with high  $\hat{I}^{\text{V}}$ , high propellant efficiency, and high electrical efficiency. Miniature ion thruster development is a NASA identified enabling technology for missions in



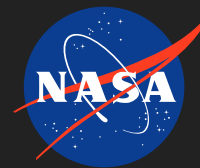
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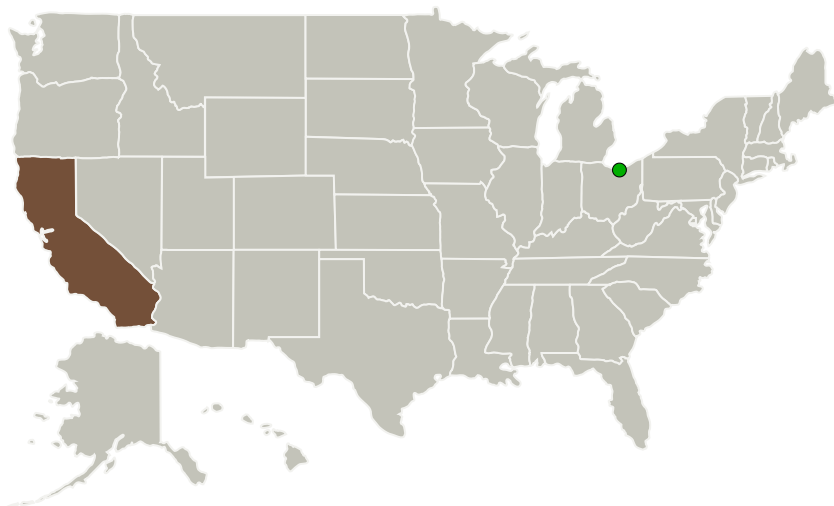
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Southern California(USC)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Los Angeles, California
● Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

## Primary U.S. Work Locations

California

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

University of Southern California (USC)

**Responsible Program:**

Space Technology Research Grants

## Project Management

**Program Director:**

Claudia M Meyer

**Program Manager:**

Hung D Nguyen

**Principal Investigator:**

Richard E Wirz

**Co-Investigator:**

Stephen A Samples

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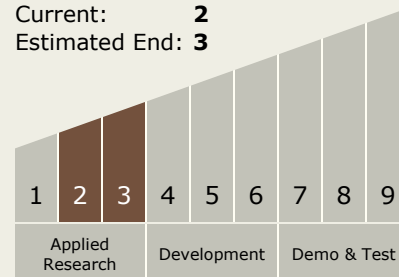


## Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

## Technology Maturity (TRL)

Start: **2**  
Current: **2**  
Estimated End: **3**



## Technology Areas

### Primary:

- TX01 Propulsion Systems
  - └ TX01.2 Electric Space Propulsion
    - └ TX01.2.2 Electrostatic

## Target Destination

Earth